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Immediate Water Pollution Control Needs, Galveston Bay Area, Texas

Federal Water Pollution Control Administration, Dallas, Tex

Apr 67

PB 266 388

IMMEDIATE WATER POLLUTION CONTROL NEEDS

GALVESTON BAY AREA

TEXAS

U. S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
SOUTH CENTRAL REGION
DALLAS, TEXAS 75202

APRIL 1967

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16. ABSTRACT

The purpose of the report is to focus attention on known sources of water pollution in this area and to provide a priority for action to correct existing problems and to prevent future problems.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Water Pollution Control Galveston Bay Texas		

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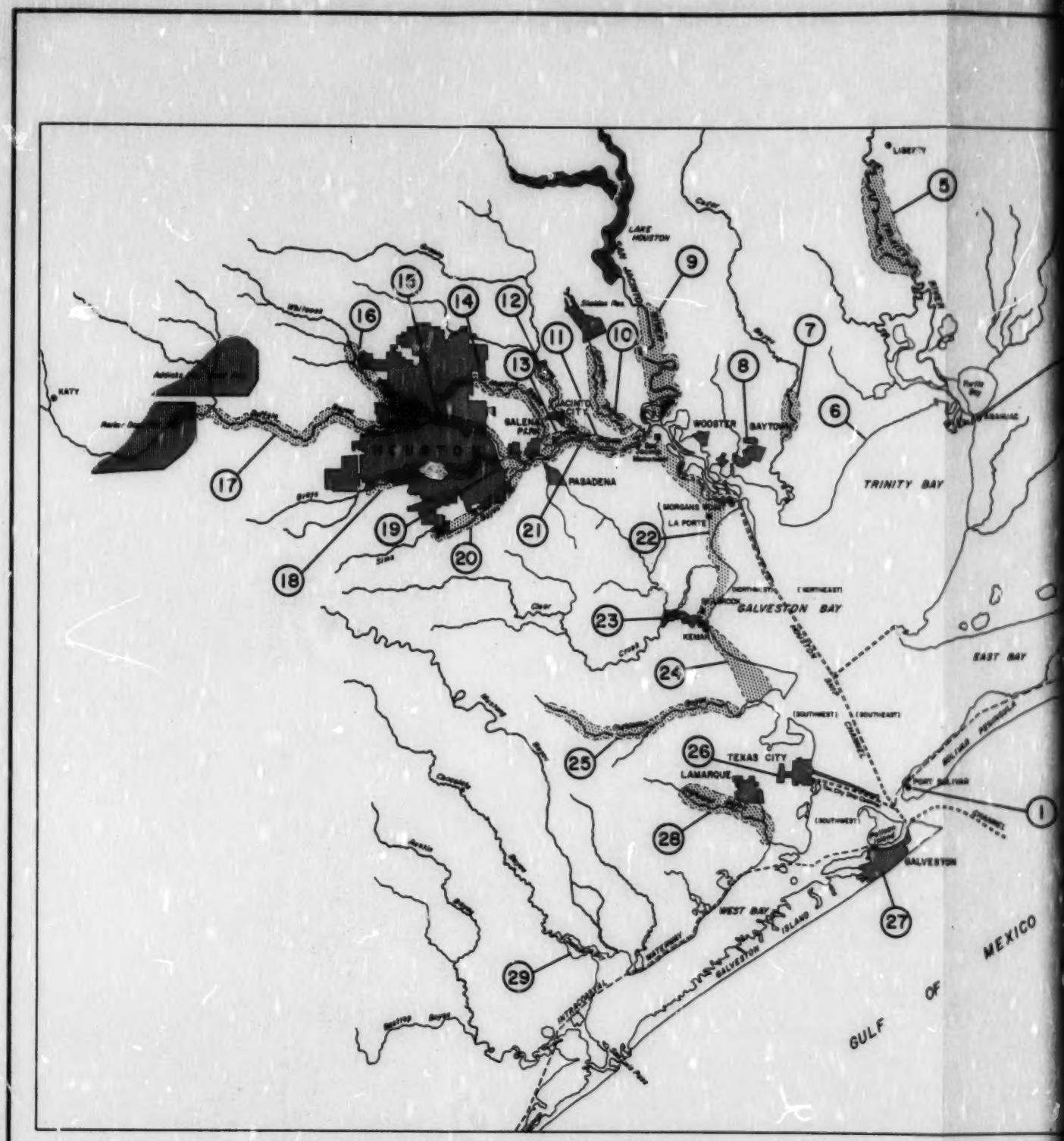
I. Introduction

The purpose of this report is to focus attention on known sources of pollution and to provide a priority for action to correct the existing water pollution problems and prevent future problems in the Galveston Bay Area (see Figure 1), a portion of the coastal waters in the State of Texas. This report is based on compilations of available data of the Federal Water Pollution Control Administration, South Central Region, and the pollution control agencies of Texas. No detailed water quality surveys or engineering studies were carried out for the preparation of this report.

The findings of this report are based on the best information available at this time on water quality conditions and immediate and potential pollution abatement needs. The omission of any particular town, industry, or other establishment from this report does not imply that an immediate or potential pollution abatement need may not possibly exist in that particular area. Priorities listed are based solely on an evaluation of the Galveston Bay Area and not on a relative basis with other basins in the South Central Region.

Authority is given in Section 3 (a) of the Federal Water Pollution Control Act, as amended, for the preparation or development of comprehensive programs for eliminating or reducing the pollution of interstate waters and tributaries thereof and improving the sanitary conditions of surface and underground waters. This report by describing the immediate needs for controlling water pollution in the Galveston Bay Area represents one step in the development of a comprehensive program to control water pollution in this area.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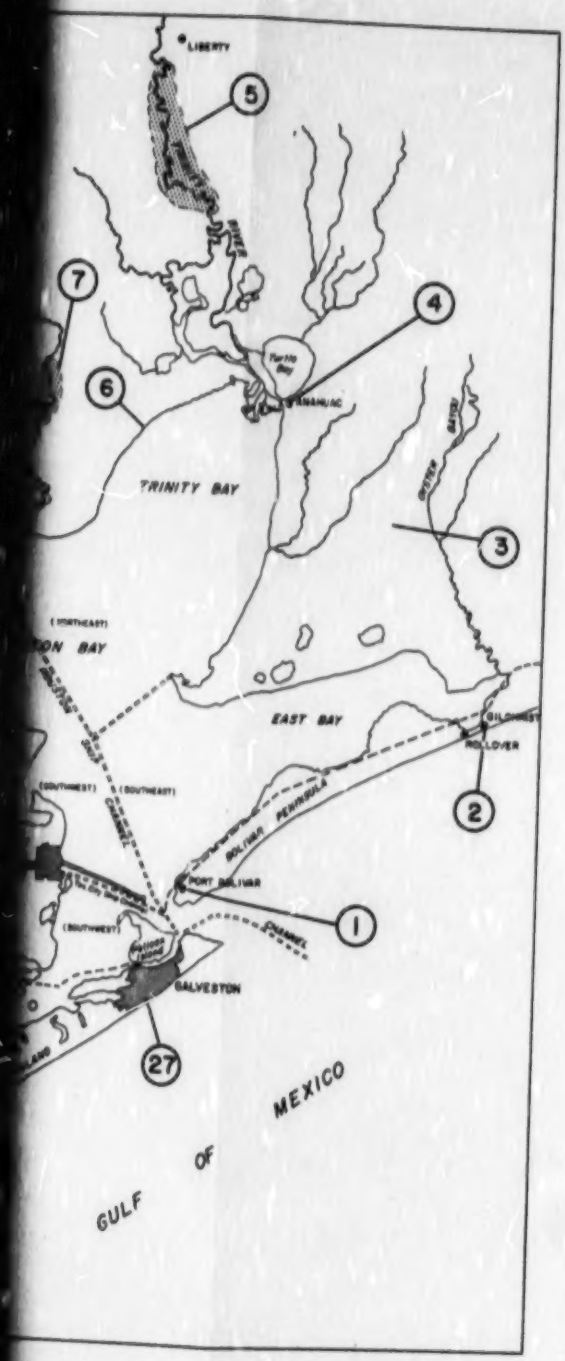

LEGEND

(2) NEEDS

MUNICIPAL AREAS

RESERVOIR AREAS

INDICATED AREAS OF WATER POLLUTION CONTROL NEED

Scale in Miles

5 0 5 10 15

IMMEDIATE WATER POLLUTION CONTROL NEEDS
GALVESTON BAY AREA - TEXAS

LOCATION MAP

UNITED STATES DEPARTMENT OF THE INTERIOR
Federal Water Pollution Control Administration
SOUTH CENTRAL REGION APR 1967 DALLAS, TEXAS

FIGURE 1

II. Summary of Immediate Water Pollution Control Needs

Pollution problems in the Galveston Bay Area, indicated by oxygen depletion, high bacterial densities, the presence of toxic materials, and heavy algal growths, result in damages to fish and shellfish propagation, industrial and cooling water uses, and recreation uses. The immediate pollution control needs are listed in the following tabulation and grouped into categories: waste treatment, institutional practices, and special studies and research. Location designations refer to figure 1.

Location	Responsibility	Need	Priority
Waste Treatment			
East Bay			
3	Barbers Hill Salt Water Company	Injection of oilfield brines or transport to Gulf of Mexico	B
2	Gilchrist (Local governmental)	Sewage collection system, primary and secondary treatment plant, chlorination	B
1	Port Bolivar (Local governmental)	Sewage collection system, primary and secondary treatment plant, chlorination	B
Trinity Bay			
4 (Anahuac area)	City of Anahuac	Sewage collection system, primary and secondary treatment plant, chlorination	A
	Humble Oil & Refining Co. (Anahuac Gas Plant)	Primary and secondary treatment, chlorination	B
6	Humble Oil & Refining Co. (Point Barrow Ofc)	Primary and secondary treatment plant, chlorination	B
5 (Trinity River area)	City of Liberty	Expansion of sewage treatment facilities, chlorination	A

Location	Responsibility	Need	Priority
	Texas Gulf Sulphur Co. (Moss Bluff Mine)	Improvement in sulfide and thiosulfate removal	A
	Northeast Galveston Bay		
7 (Cedar Bayou area)	Gulf Oil Corp. (Cedar Bayou Plant)	Expansion of secondary treatment facilities	B
	J. M. Huber Corp.	Expansion of settling facilities	B
	Chambers County WC&ID No. 1	Expansion of secondary treatment	B
8 (Baytown area)	City of Baytown	Expansion of sewage treatment facilities	B
	Enjay Chemical Co.	Preliminary, primary, & secondary treatment plant	A
	Humble Oil & Refining Co. (Baytown Refinery)	Improvement of preliminary, primary, & secondary treatment facilities	A
9(San Jacinto River area)	Arcadia Land & Utilities Co.	Improvement of chlorination facilities	A
	Harris County WC&ID No. 73	Improvement of chlorination facilities	A
	Harris County WC&ID No. 1	Expansion of sewage treatment facilities	B
	Houston Ship Channel		
10 (Carpenters Bayou)	Some local governmental unit	Areawide sewage collection system, central sewage treatment plant	B
11 (Carpenters Bayou to Greens Bayou)	Association of Industrial plants	Area industrial waste collection system, central industrial waste treatment plant	A

Location	Responsibility	Need	Priority
12 (Greens Bayou)	City of Houston or Some Local Governmental Unit	Areawide Sewage Collection System, Central Sewage Treatment Plant	A
13 (Greens Bayou to Hunting Bayou)	Koppers Company, Inc.	Preliminary, Primary, and Secondary Treatment Plant	A
	City of Jacinto City	Expansion of Sewage Treatment Facilities	B
	Sheffield Div., Armco Steel Corp.	Preliminary, Primary, and Secondary Treatment Plant	A
	Todd Shipyard Corp.	Primary and Secondary Treatment Plant	A
14 (Hunting Bayou)	City of Houston	Areawide Sewage Collection System, Central Sewage Treatment Plant	A
15 (Hunting Bayou to White Oak Bayou)	Brown and Root, Inc.	Provision of Settling Facilities	A
	Drumex, Inc.	Preliminary and Primary Treatment Plant	A
	Hess Terminals	Improvement of Skimming and Settling Facilities	A
	Hooker Chemical Corp.	Primary and Secondary Treatment Plant, Chlorination	A
	Horton and Horton, Inc.	Provision of Settling Facilities	A
	City of Houston (Clinton Park Plant)	Expansion of Sewage Treatment Facilities	B
	City of Houston (Northside Plant)	Expansion of Sewage Treatment Facilities	A

Location	Responsibility	Need	Priority
	Humble Oil & Refining Co. (Special Products Plant)	Primary and Secondary Treatment Plant	B
	Ideal Cement Co.	Provision of Settling Facilities	B
	John Young Co.	Provision of Settling Facilities	A
	United States Gypsum Company	Primary and Secondary Treatment Plant	A
	Velsicol Chemical Corp.	Preliminary, Primary, and Secondary Treatment Plant	A
16 (White Oak Bayou)	City of Houston or Some Local Governmental Unit	Areawide Sewage Collection System, Central Sewage Treatment Plant	A
17 (Buffalo Bayou Upstream from White Oak Bayou and Upstream from Brays Bayou)	Armour Agricultural Chemical Co.	Preliminary, Primary, and Secondary Treatment Plant	A
	Cameron Iron Works, Inc.	Preliminary and Primary Treatment Plant	A
	City of Houston or Some Local Governmental Unit	Areawide Sewage Collection System, Central Sewage Treatment Plant	A
	City of Katy	Expansion of Sewage Treatment Facilities	A
	National Molasses Co.	Primary and Secondary Treatment Plant	A
	Trinity Portland Cement Div., General Portland Cement Co.	Provision of Settling Facilities	A

Location	Responsibility	Need	Priority
18 (Brays Bayou)	City of Houston or Some Local Governmental Unit	Areawide Sewage Collection System, Central Sewage Treatment Plant	A
19 (Brays Bayou & Sims Bayou)	Parker Brothers & Co., Inc.	Provision of Settling Facilities	A
	Signal Oil & Gas Co.	Preliminary, Primary, and Secondary Treatment Plant	A
20 (Sims Bayou)	Best Fertilizers Co.	Provision of Settling Facilities	A
	Goodyear Tire & Rubber Co.	Expansion of Treatment Facilities	B
	City of Houston	Areawide Sewage Collection System, Central Sewage Treatment Plant	A
	City of Houston (Sims Bayou Plant)	Expansion of Sewage Treatment Facilities	B
	Shaw Tank Cleaning Co.	Preliminary, Primary, and Secondary Treatment Plant	B
21 (Sims Bayou to San Jacinto Monument)	Champion Papers, Inc.	Preliminary, Primary, and Secondary Treatment Plant	A
	Crown Central Petroleum Corp.	Preliminary, Primary, and Secondary Treatment Plant	A
	Diamond Alkali Co.	Provision of Settling Facilities	A
	Horton and Horton, Inc.	Provision of Settling Facilities	A

Location	Responsibility	Need	Priority
21 (Sims Bayou to San Jacinto Monument)	The Lubrizol Corp.	Preliminary, Primary and Secondary Treatment Plant	A
	Olin Matheson Chemical Corp.	Expansion of Treatment Facilities	B
	Parker Brothers & Co., Inc.	Provision of Settling Facilities	A
	Phosphate Chemicals, Inc.	Provision of Settling Facilities	B
	Rohm and Haas Co.	Preliminary, Primary, and Secondary Treatment Plant	A
	Shell Chemical Co.	Preliminary, Primary, and Secondary Treatment Plant	A
	Shell Oil Company	Expansion of Treatment Facilities	B
	Sinclair Refining Co.	Preliminary, Primary, and Secondary Treatment Plant	A
	Tenneco Manufacturing Company	Preliminary, Primary, and Secondary Treatment Plant	B
	U. S. Industrials Chemicals Co.	Expansion of Settling Facilities	B
Northwest Galveston Bay			
22 (San Jacinto Monument to Clear Lake)	The Carwin Co.	Preliminary, Primary, and Secondary Treatment Plant	A
	Celanese Plastics Co.	Expansion of Secondary Facilities	B

Location	Responsibility	Need	Priority
	Humble Oil & Refining Co. (Bayport Industrial Plant)	Expansion of Treatment Facilities	B
23 (Clear Lake)	Some Local Governmental Unit	Areawide Sewage Collection System, Central Sewage Treatment Plant	A
24 (Clear Lake to Dickinson Bayou)	Humble Oil & Refining Company	Primary and Secondary Treatment Plant	A
25 (Dickinson Bayou)	Galveston County or Some Local Governmental Unit	Areawide Sewage Collection System, Central Sewage Treatment Plant	A
Southwestern Galveston Bay			
26 (Texas City Area)	Association of Industrial Plants	Central Industrial Wastes Treatment Plant	A
27 (Galveston Area)	City of Galveston	Expansion of Sewage Treatment Facilities	A
	Gulf, Colorado, and Santa Fe Railway Co.	Primary and Secondary Treatment Plant	A
	Todd Shipyards Corp.	Primary and Secondary Treatment Plant	A
	U. S. Coast Guard	Secondary Treatment & Chlorination Facilities	A
28 (Highland Bayou)	Galveston County or Some Local Governmental Unit	Areawide Sewage Collection System, Central Sewage Treatment Plant	B
West Bay			
29 (Chocolate Bay Area)	Humble Oil & Refining Company	Primary and Secondary Treatment Plant, Chlorination	B

Location	Responsibility	Need	Priority
	Monsanto Chemical Co.	Secondary treatment	B
	Phillips Petroleum Co.	Primary and secondary treatment plant	B
Institutional Practices			
Areawide	State of Texas	Adopt use designations for the various waters of the Galveston Bay system in order to clarify water quality requirements for the individual areas.	A
Areawide	State of Texas	Adopt water quality standards for the entire Galveston Bay system	A
Areawide	State of Texas	Provide additional personnel for surveillance of the water quality of the Galveston Bay system and of the various discharges to the system.	A
Areawide	State of Texas	Consider legislation to provide appropriations for State participation in grants for construction of sewage treatment works	B
Areawide	State of Texas	Prepare and maintain a complete industrial waste discharge inventory for industries not connected with municipal treatment systems	B
Special Studies and Research			
Areawide	State of Texas	Institute a complete compilation and collation of all data from previous general and specific studies of the Galveston Bay system	A

Location	Responsibility	Need	Priority
Areawide	State of Texas	Carry out a complete study of the Galveston Bay system in order to fully delineate the various factors affecting the quality of the waters of the Galveston Bay system that have not been completely evaluated in previous studies.	B
Areawide	Federal Government State & local governmental agencies, & institutions of higher learning	Initiate correlated research on the control of salinity and nutrient buildup in shallow bay systems	B

III. Immediate Water Pollution Control Needs

The principal water pollution control needs for the Galveston Bay system are the prevention of oxygen depletion and the reduction of the bacterial density, particularly coliform organisms. Both needs involve the reduction of the organic materials now being discharged to the bay system. The reduction in the organic materials will also result in the reduction of other objectionable materials such as toxic compounds and settleable solids. In addition to receiving secondary treatment, municipal wastes need to be disinfected prior to release.

This listing of immediate water pollution control needs is not considered all inclusive and does not reflect the ultimate in precision and detail in evaluating alternatives. However, it is believed the treatment improvements and actions suggested are prerequisite to the maintenance and improvement of the water quality of the Galveston Bay system. Background for these immediate needs is summarized in Chapter VI.

Waste Treatment

The highest priority is placed on the upgrading of those industrial effluents with an excessive organic content and on improvements that will insure a consistently high degree of treatment for the domestic sewage of the area. Improvements are needed at some 34 industrial locations and 8 municipal plants. In some cases, other considerations, such as excessive inorganic suspended solids, led to the assignment of a high priority.

Most of the needed treatment improvements are in the northwestern Galveston Bay Area (including the Houston Ship Channel and its tributaries and Clear Lake) and in the southwestern Galveston Bay Area in the vicinity of Texas City. These two areas include the majority of the industrial plants and population concentrations of the Galveston Bay Area. While some of the high volume discharges contribute the major portion of the organic material, the accumulated total of the organic content of the many small discharges of the area represents a substantial load on the receiving waters. The treatment improvement needs of the smaller discharges are considered equally as important on a cumulative basis as the needs for improvements in treatment of the individual larger discharges.

In several watersheds, there are numerous small sewage treatment plants serving limited areas of the basin. It is believed that the areawide collection of the sewage and its treatment at a central plant would provide more effective pollution control not only for the specific watershed but also for the Galveston Bay system as a whole. These eight watershed projects are designated in the summary table.

Somewhat the same is true in some of the concentrated industrial areas. In addition to the possible more economical construction and operation of a common plant, the severe space limitations of various individual industrial plants could be overcome. Two such areas are designated in the summary table.

As the Galveston Bay Area grows, it will be necessary to further reduce the pollutional load at individual locations in order to maintain the overall load on the bay system within some maximum limit. Treatment improvements for some 28 locations, estimated to be needed for this purpose, are included in the summary table but at a lower priority than those needs discussed above.

Institutional Needs

The establishment of uses and water quality standards for the waters of the Galveston Bay system where such action has not been previously taken needs official action by the State of Texas in the near future. The official designation of the uses and quality standards will aid materially in the present pollution control activities and the planning of future activities.

Increased surveillance and operation inspection of sewage and industrial waste treatment plants are needed to locate and identify existing or potential serious pollution problems. State participation is needed in the waste treatment plant construction grants program to accelerate the construction of needed improvements. For more rigid control over industrial pollution and to aid in solving complex water quality problems, a complete and up-to-date inventory is needed of industrial waste discharges to bay area waters, listing quantity and quality of effluent and other pertinent data.

Special Studies and Research

A number of special studies have been made of the Galveston Bay system by Federal, State, and local governmental agencies as well as by private groups. The results of these studies need to be compiled and collated. Pursuant to this initial study, the State of Texas with the cooperation of Federal and local governmental agencies and private interests should undertake a complete study of the present water quality of Galveston Bay and of methods for future water pollution control in the bay system.

An overall need is the evaluation of the various factors governing the salinity and nutrient buildup in shallow bay systems. While this need applies to most shallow bay systems and not to Galveston Bay alone, a coordinated research program directed toward the full delineation of the general parameters governing the buildups would be quite valuable in the future control of the quality of the Galveston Bay system.

IV. Water Pollution Control Costs

Waste Treatment Improvement Costs

Domestic Sewage Treatment Facilities - It is estimated that $155,000,000 will be needed for improvements in the treatment of the sanitary sewage of the Galveston Bay Area. Included in this estimate are improvements at 12 sewage treatment plants and the replacement of 135 sewage treatment plants by areawide collection systems and central sewage treatment plants. Also included in the central sewage treatment facilities are the wastes from 62 small industrial plants.

Industrial Waste Treatment Facilities - It is estimated that $103,000,000 will be needed for improvements in the treatment of the industrial wastes of the Galveston Bay Area. Included in this estimate are treatment improvements at 53 industrial plants and the inclusion of the wastes from 20 industrial plants into central industrial waste treatment plants.

The total estimated cost for expansion and improvements of the treatment facilities in the Galveston Bay Area is $258,000,000. Of the total waste treatment cost, approximately $224,000,000 would be needed for control measures listed under priority "A" in the summary table.

Operating Costs

As the improvements are made, it will be necessary to provide funds to cover the additional operating costs of the new and improved treatment units. Only a very rough estimate can be made of these additional operating costs at this time. With this understanding, it is estimated that the additional annual operating costs will be about $4,000,000 for the industrial waste treatment improvements and about $2,000,000 for the domestic sewage treatment improvements.

Pollution Surveillance Costs

It is estimated that the pro rata share of the cost of additional pollution surveillance of Galveston Bay as part of a regional organization will be about $200,000 annually.

Special Studies and Research Costs

It is estimated the compilation and collation of existing data will cost about $50,000. An overall survey and evaluation of the various parameters governing pollution control in the Galveston Bay system is estimated to cost approximately $3,000,000.

No estimate has been made of the cost of the overall research on salinity and nutrient buildup in shallow bay systems.

V. Recent Progress in Pollution Control

The Texas Water Pollution Control Law (Article 7621d, Vernon's Civil Statutes) was passed in 1961 and became fully effective in November 1962. This law required permits for the discharge of any waste waters that may cause pollution. At present, administration of the law is carried out under a seven man Texas Water Pollution Control Board (TWPCB).

The law provided for the issuance of statutory permits to continue discharges existing at the time of its passage. After its initial effort to inventory all existing waste discharges, the major effort of the TWPCB has been expended in three areas. These have been Galveston Bay, oil field brines throughout the state and localized problem areas.

Soon after its organization, the TWPCB indicated its concern as to possible water quality problems in the Galveston Bay Area. On September 6, 1962, it requested that the Texas State Department of Health and the Texas Parks and Wildlife Department undertake a joint investigation of the qualities of the waters of Galveston Bay. This study was initiated on March 13, 1963, and is continuing. On May 15, 1963, the TWPCB retained the University of Texas to compile the existing data from previous surveys by Federal, State, and local governmental agencies and private groups. This report was submitted March 1, 1964. Under a contract designated WA66-1, Texas A & M University, Texas Technical College, and The University of Texas submitted a report titled "Work Plan for the Development of a Comprehensive Water Quality Management Program for Galveston Bay and its Tributaries" to the Secretary of the U. S. Department of the Interior and the Chairman of the Texas Water Pollution Control Board. A complete investigation based on this report is now under consideration.

The creation of an overall authority for the Galveston Bay Area is presently under consideration by the State of Texas. The responsibilities of the authority, presently termed "Galveston Bay Area Authority", would include water pollution control matters. It is understood that legislation creating the authority is being drafted and will be considered by the Texas Legislature at a special session to be called in the near future.

Other than the investigative and legislative activities outlined above, the official actions of the TWPCB in the Galveston Bay Area can be generally classified as follows:

Clear Lake Control Activities
Houston Ship Channel Control Activities
Permit Issuance

Clear Lake - The Houston NASA complex is located in the Clear Lake watershed. Because of concern as to the effect of the rapid development of the area on the water quality of Clear Lake, the TWPCB held hearings in the area. As a result of these hearings it was determined that the quality of the water in Clear Lake was to be maintained suitable for recreational purposes.

An active program for upgrading the effluents being discharged in the Clear Lake watershed was undertaken and is being continued by the TWPCB. The permit requirements for industrial discharges are tailored to each individual case. At the present time, the industrial wastes represent a minor amount of the total waste waters. The permit requirements for treated domestic sewage are somewhat standardized.

While the permits for treated domestic wastes vary in wording, they generally require that the final effluent have a BOD of less than 20 ppm and a total suspended solids content of less than 20 ppm. They also contain a provision requiring a 1.0 ppm chlorine residual after 20 minutes contact time. In addition there are generally two special provisions requiring the connection of the sewer system into a central system where one becomes available and requiring compliance with a TWPCB resolution of August 6, 1964. This resolution established certain record and test procedures to be followed to assure high operational efficiency for all sewage treatment plants in the Clear Lake watershed.

The active program of the TWPCB has resulted in an overall improvement of the quality of the effluents discharged in the Clear Lake watershed. While some new plants have been built and major changes made at others, it is believed more consistent operation of the existing plants has accounted for a major portion of the effluent quality improvements.

Houston Ship Channel - The quality of the water in the Houston Ship Channel and its uses have been the subject of much discussion for a number of years. There have been strong and diametrically opposed opinions on the uses and qualities of the channel waters over the years. In order to obtain all sides of the question, the TWPCB held a public hearing in Houston, Texas, on June 17, 1964. The TWPCB took the matter under advisement at that time.

Subsequent to the public hearing, the TWPCB issued two press releases with the first being on September 24, 1964. In general, these press releases expressed the Board's intention to maintain the waters of the Houston Ship Channel above Morgans Point suitable for navigation and commercial use. The press releases also expressed the intention of the Board to maintain the quality of the Channel waters at a level high enough to protect the uses of Galveston Bay waters.

At the request of the TWPCB, two reports were prepared by a staff member of the Texas State Department of Health. These two reports entitled "Houston Ship Channel and its Tributaries above Morgans Point - A Report and Proposed Water Quality Criteria" and "Houston Ship Channel and its Tributaries above Morgans Point - A Plan for the Control and Improvement of Effluents" were presented to the TWPCB in February 1965. These reports were widely distributed by the Board for review and comment. Hearings, continued through several months of 1965, were held on the merits of the recommendations contained in the above reports and various alternates.

On December 2, 1965, the TWPCB adopted Order No. 65-9, which embodied the recommendations of the above reports with some minor changes. The order established water quality objectives for the Houston Ship Channel above Morgans Point and effluent objectives for discharges to this portion of the Houston Ship Channel.

As instructed, the TWPCB staff has been holding conferences with the permittees of the area in order to develop compliance with Order No. 65-9 at individual discharge points. It is understood that conferences have been held to date with about 80 industries and most of the municipalities. These conferences have resulted in general agreements for the construction of waste treatment plants at a number of locations and major improvements in the treatment facilities of other locations. A number of permits have been amended to reflect the requirements of the order. The conferences, amendment of permits, and other activities in connection with the TWPCB Order 65-9 are continuing.

VI. Background

Basin Characteristics

General

Galveston Bay is located on the mid-upper Gulf Coast of Texas at approximately 29°24' longitude and 94°50' latitude. The bay system consists of the main bay and its various arms covering approximately 335,000 surface acres. The bay system is "landlocked" behind Bolivar Peninsula and Galveston Island with connections to the Gulf of Mexico through Rollover Pass in its eastern portion, Bolivar Roads near its midpoint, and San Luis Pass at its southwestern extremity.

The various arms and estuarine areas making up the Galveston Bay system are designated as follows:

East Bay
Trinity Bay
Northeastern Galveston Bay
Northwestern Galveston Bay
Southwestern Galveston Bay
Southeastern Galveston Bay
West Bay

There have been a number of navigation channels dredged through the bay system. Oceangoing traffic enters the bay system at Bolivar Roads through the Inner Bar Channel. Galveston Channel, serving the Port of Galveston, branches off at Bolivar Roads and extends between Galveston Island and Pelican Island to the west end of Pelican Island. The Houston Ship Channel proceeds some 50 miles from Bolivar Roads to its termination at the Port of Houston. About half of this channel is in Galveston Bay with the other half being along the stream bed of Buffalo Bayou. The Texas City Channel proceeds through Galveston Bay from Bolivar Roads to the Texas City Turning Basin.

The Intracoastal Waterway enters and leaves Galveston Bay at a number of points. After crossing a narrow arm of East Bay, the waterway proceeds along Bolivar Peninsula and re-enters Galveston Bay at Bolivar Roads. It leaves the bay again shortly after its entrance into West Bay and then re-enters at Chocolate Bay. After crossing Chocolate Bay, it leaves the Galveston Bay system and proceeds southward along the Texas Gulf Coast.

Physical Characteristics

Overall Bay Area and Depth: The Galveston Bay system covers a total of about 335,000 surface acres. The overall bay system is shallow with reefs and shell banks throughout its area. The bay system averages about seven feet (ft.) in depth with a maximum depth of about 15 ft. in limited areas. Large areas of three to four foot water exist particularly in the various arms of the major bay.

The major navigation channels range in depth from 35 to 40 ft. with widths ranging from about 300 to 1200 ft. These channels are semiconfined by the spoil from the dredging operations. For instance, the waters adjacent to the Houston Ship Channel are about three feet in depth on both sides. The spoil from the Texas City Channel was deposited on one side (northeast) forming a long narrow peninsula or dike with the south side of the channel being about the normal depth of the bay. The smaller barge channels are generally about eight feet in depth.

Climatic Conditions: The overall climatic conditions vary slightly over the Galveston Bay system due to its size and location. The bay borders on the Gulf of Mexico and on mainland areas some 25 miles (mi.) inland. While the overall variation is not great, variable conditions at specific times can have a material effect on water quality control in the bay area.

Local rainfalls on the headwaters of the tributaries without rain downstream has the effect of "pushing" accumulated waste waters into the bay without any general dilution. This is particularly true of the Houston Ship Channel. The generally higher and lower temperatures experienced inland has some effect on the relative temperatures of the bay waters near the mouths of the tributaries.

The prevailing winds of the area are southeast. However, the area experiences strong prolonged winds from any direction from time to time. Strong northers, although infrequent, occur during most winter seasons. These strong northerly winds tend to push the waste waters from the inland areas into the bay system at a rapid rate. Some fish kills have been credited to the rapid entrance of the waste water from the Houston Ship Channel.

Fresh Water Inflow: The greatest sources of fresh water inflow to Galveston Bay are the Trinity River, San Jacinto River, and Buffalo Bayou. In addition to these major sources, there are numerous smaller streams that discharge either to Galveston Bay or the Houston Ship Channel.

While the streams of the area have historically supplied ample fresh water to the bay system, the development of upstream water supply reservoirs has diminished the inflow measurably in recent years. The San Jacinto River has been dammed a short distance above its mouth to form a water supply reservoir for the City of Houston. All the major headwater tributaries of the Trinity River have been dammed to form water supply reservoirs for the Dallas-Fort Worth area. Dams have also been constructed on many of the major

downstream tributaties of the Trinity River. Flood control structures on Buffalo Bayou regulate the flow of that stream but do not materially alter the overall flow.

A number of additional reservoirs are planned for the Trinity and San Jacinto River Basins. The reservoirs in the Trinity Basin will be on both the main stem and the tributaries. Since the main stem of the San Jacinto River is already dammed, the additional reservoirs in the San Jacinto Basin will be on the tributaries above the Lake Houston Dam.

It is anticipated that the development of new reservoirs in the Trinity and San Jacinto River Basins will further diminish the fresh water inflow to the Galveston Bay system. Unless programmed releases are made for water quality control in the near future, there will be no fresh water flow below the last downstream reservoir for long periods of time. The San Jacinto River and the smaller streams cannot now be counted on to consistently provide fresh water dilution water to the bay system.

Tidal and Wind Exchange: The Galveston Bay system has three tidal passes through which the bay waters may exchange with Gulf of Mexico waters. The main pass between Bolivar Peninsula and Galveston Island is Bolivar Roads. The overall pass is about 3,000 yards wide with a normal depth of 20 feet. The oceangoing channel dredged through the pass is about 300 yards wide and 40 feet deep.

Rollover Pass is near the east end of East Bay and cuts through Bolivar Peninsula. This is a tidal pass with water flowing as a stream from the Gulf of Mexico to East Bay at high tide and from East Bay to the Gulf of Mexico at ebb tide.

St. Luis Pass is a natural pass at the south end of Galveston Island which connects West Bay with the Gulf of Mexico. The pass itself ranges in depth from three to twenty-five feet. However, the bay end of the pass is only from one to five feet deep and the Gulf end only two to ten feet deep. There is considerable evidence of strong eddy currents in the pass.

High tides along the Texas Gulf Coast seldom exceed two feet with ebb tides in the vicinity of one foot. Thus, the net change in tidal depth of the bay system rarely exceeds three feet. In general, the maximum tidal changes occur in the October through April period with the minimum changes occurring in the May through September period.

During calm days somewhat normal tidal mixing, diffusion, and exchange takes place in Galveston Bay. Salt water wedges can be

observed in the navigation channels through the bays. However, the wedges are often muted due to the mixing effects of navigational traffic.

Due to the shallow nature of the bay system, strong prolonged winds materially affect the tidal action on the bay system. During these periods no apparent change in the bay elevation takes place over a tidal cycle. This is particularly true in the upper end of the bay. It has been reported that at times sampling stations normally reached by boat are completely dry due to the effect of the wind on the waters of the bay system. While it can be said that there is a normal tidal exchange of bay waters with Gulf waters over a period of time, the net exchange during limited periods of time is often governed more by wind direction and velocity than it is by the tide.

The net exchange rate of bay waters with Gulf waters is dependent on the ratio of inflowing waters to total bay volume. While return flows have increased in recent years, the fresh water inflow has been materially reduced through the development of water supply reservoirs. It is anticipated that the net exchange rate will be further reduced as more water supply reservoirs are developed on the streams discharging to the Galveston Bay system. Based on only the mean fresh water inflow for the water year 1963-64, the net exchange rate is estimated at 0.0017/day. The maximum flows for that year, assuming they all came at the same time, yield a net exchange rate of 0.031/day. Further reduction of the fresh water inflow through development of upstream reservoirs will likely decrease materially this already low exchange rate.

Area Development

General: Galveston Bay is almost completely surrounded by developments. Only the extreme east side of the bay is relatively free of municipal or industrial development. The municipal and industrial growth of the area has been at a very rapid pace in the post World War II period. Although the pace of the growth may slow gradually, it is anticipated the growth of the area will continue at a relatively rapid rate for some time to come. It is estimated that the population of Galveston Bay drainage basin (excluding the Trinity River) is in the vicinity of two million people at the present time.

Municipal Development: It is almost impossible to separate the various municipalities of the area except by boundary lines on a

map. However, the population centers can be placed into five overall classifications, which are:

Houston Metropolitan Area
Texas City Metropolitan Area
Galveston Metropolitan Area
Baytown Metropolitan Area
Scattered Communities.

East Bay, Trinity Bay, and West Bay are relatively free of municipal development with only small communities on their shores. The existing communities are fishing resorts and supply centers for local residents (farmers, tourists, facility operators, oil field workers, etc.). Except for a portion of Galveston, West Bay does not have any organized communities located along its shores.

The shores of the remainder of the bay system are densely populated. Starting with Baytown on the north shore and proceeding in a counter clockwise direction, one finds a continuous "city" to Galveston. This overall "city" is made up of numerous incorporated communities, including the Baytown, Houston, Texas City, and Galveston metropolitan areas. Most of the population of the bay area is located in these municipalities. The physical location of this population dictates that their treated waste waters must pass through a major portion of the bay system prior to reaching the Gulf of Mexico. For example, Houston straddles Buffalo Bayou which discharges into the upper end of Galveston Bay. Practically all the local drainage streams of the Houston area discharge to Buffalo Bayou or the Houston Ship Channel.

Industrial: The industrial development of the area follows to a great extent the same pattern as the municipal development. East Bay, Trinity Bay, and West Bay are relatively free of concentrated industrial development. However, these bays do have isolated industrial plants located on their immediate watershed. In addition, there are indications that industrial development will spread to the watersheds of these bays in the near future.

The most dense industrial development is along the navigational channels. In a counter clockwise direction, there is an almost continuous series of industrial plants from Baytown on the north shore to Texas City on the south shore of Galveston Bay. In general, it can be said the major industrial complexes have developed where ocean-going or barge navigational facilities are available.

While many of the industrial plants are petroleum or petro-chemical based, there is a wide variety in the industrial complex.

Paper mills, cement plants, steel mills, food processing plants, etc. are interspersed among the refineries and petrochemical plants.

The major wet industrial complexes are located in four general areas, as follows:

Baytown Area
Houston Ship Channel Area
Northwestern Galveston Bay Area
Texas City Area

Other industrial plants are scattered throughout the remaining area. It is quite likely that these other areas, such as Chocolate Bayou on West Bay, will develop in the not too distant future. Historically as a basic industry has been located in the area, satellite industries have gradually been established surrounding the basic industry.

Recreational: Most of the Galveston Bay system is used for recreational purposes. Only the Houston Ship Channel, the industrial harbors, and some isolated small bay areas do not accommodate some form of recreational activity.

Boat havens are maintained throughout the bay area. Most of the major havens are at Galveston, Texas City Dike, Kemah, Seabrook, Clear Lake area, LaPorte, Baytown, Port Bolivar, Gilcrist, and Rollover.

Tourist facilities are located at scattered points around Galveston Bay. However, the major development of tourist facilities is on Galveston Island and is primarily related to the Gulf of Mexico. The major organized beach areas are on the Gulf coast side of Galveston Island.

While some swimming is done at various beaches on Galveston Bay proper, most of the water contact sports are restricted to the small bays off the main body of water. The main body of Galveston Bay is generally too rough for water skiing and only a limited number of beach areas are open to the public. Numerous beach houses dot the shores of Galveston Bay between the industrial areas. The individuals owning these beach houses probably wade in the bay. A related swimming area, not connected directly to Galveston Bay, is the Gulf side of Galveston Island and Bolivar Peninsula.

Recreational fishing is done in all parts of the bay system, both from the bank and by boat, with the exception of the Houston

Ship Channel and the industrial harbors. It has been estimated that fishermen caught fish during 73 percent of their fishing days. Bait houses are located throughout the Galveston Bay area.

Agricultural: As late as 1960, Harris County (Houston) ranked as the number one cattle producing county in the State of Texas. At that time many large ranches were located in the coastal area bordering Galveston Bay. While the county may still rank first, much of the ranch land in the coastal area has been overrun by industrial and residential development. For example, the NASA complex is situated in the middle of one of the former large ranches.

Rice farming is still carried out on a major scale. Until recently, there has been little encroachment on the farming lands to the east and northeast of the bay system. While there is still major farming operations to the south and southwest of the bay system, the farm lands of this area are diminishing through residential and some industrial development.

Water Uses

General: The waters of the Galveston Bay system are used for a variety of legitimate purposes. These uses include but are not restricted to recreation, recreational and commercial fishing, navigation, industrial cooling, some industrial process waters, shellfish production, and fish spawning and nursing. The usefulness of the waters for certain purposes has been impaired over the years by the pollutional materials discharged to the bay system. A full appraisal of the extent of the impairment is quite difficult and has not been accomplished to date. However, some general conclusion, such as those covered below, are apparent.

Recreation: There is no question that recreational activities have been somewhat curtailed over the years. How much of this curtailment has been due to water quality degradation and how much has been due to shore development is most difficult to differentiate. The development of residential and industrial sites along the shores of the bays has materially reduced public access to the beach areas.

The appearance of the waters of the bay system is connected to water quality. Undoubtedly, the appearance of the water and the known presence of municipal or industrial discharges has been a factor in the reduction of recreational activities in certain portions of the bay system and its tributaries. This would be particularly true in the vicinity of the Houston Ship Channel area. However, Harris County maintains a public park on the shores of the northwest portion

of Galveston Bay in the general vicinity of where the channel waters enter the bay system. This park is used for picnicking, swimming, wading, and pier fishing.

Recreational Fishing: The actual cause in any curtailment of recreational fishing is, like other recreational activities, hard to pinpoint. Decreasing public bank access is probably as great a factor, if not greater, than is water quality degradation; however, there have been periodic fish kills in the bay system. These kills are an indication of impairment of the recreational fishing use of the bay system due to water quality degradation.

Commercial Fishing and Shellfish Production: Reported data for recent years indicate an increase in the commercial fish catch. While the commercial fish catch in limited areas of the bay system may have been impaired by poor water quality, the reported catches would indicate either some improvement in water quality or a greater amount of fishing. It is possible that the former is true since the bay was experiencing a recovery from a drought period immediately preceding the fish data reporting period. The commercial fish catch represents only a small percentage (estimated as 3.9 percent) of the total commercial fisheries of the bay. Probably one reason for this low percentage is that netting is prohibited in Galveston Bay. In any event, the periodic fish kills experienced in portions of Galveston Bay are an indication of some impairment of the commercial fishing use of the bay waters.

Shellfish production, including oysters, blue crab, and shrimp, represents the greatest percentage of the commercial fisheries of Galveston Bay. It has been reported that oysters represent 27.7 percent, and shrimp 58.5 percent of the total fisheries. These percentages apply to Galveston Bay. In the case of shrimp, the percentage probably represents only a portion of the total productivity since most of the shrimping operations are in the Gulf of Mexico. At least a portion of the shrimp catch in the Gulf of Mexico migrated from Galveston Bay.

The commercial catch of blue crab has increased in recent years. This increase in catch is mostly due to the greater demand for blue crab, which has resulted in greater activity in their harvesting. It is not believed the greater catch indicates any increase in the blue crab productivity. Since the blue crab tolerates a lesser quality of water than most other aquatic life, they appear to have been less affected by the water quality degradation.

Both shrimp and blue crab have been noted at times during fish kills. Although in comparison to "fish" their numbers have been

small, their presence in the observed kills would indicate some impairment of the commercial fisheries use of the waters.

A large portion of Galveston Bay is now closed to commercial oyster production. A portion of the closed area is due to the vicinity of the area to known discharge points. Under present regulations these areas would probably remain closed regardless of the water quality of the area. Improvement in the water quality could result in the reopening of some of the areas remote from shore.

Navigation: It does not appear that the navigational use of the overall bay system has been impaired by pollutional material. In the confined channels, such as the Houston Ship Channel above the San Jacinto Monument, there is no doubt that the suspended solids discharged by the municipal and industrial plants have contributed to the siltation of the channel. Although these suspended solids may be a relatively small portion of the total siltation load, they do contribute to the dredging costs of the channels.

There have been allegations that the waters of the Houston Ship Channel are highly corrosive and damage the ships using the Port of Houston. There is still considerable question as to the validity of these allegations. Certainly any study of this area would need to include an evaluation of the corrosion problem if it exists.

Industrial Cooling Waters: The waters of the bay system are used for industrial cooling, with the cooling equipment being designed for saline water use. The limitation, if any, on the use of the water for industrial cooling is economic. Specific data in this regard is not readily available, particularly in respect to the corrosive properties of the Galveston Bay waters as compared to other saline waters. It is postulated that the high organic content of the waters of the Houston Ship Channel would necessitate stronger doses of aquatic growth control materials and thus increase the cost of using the water for industrial cooling.

Present Water Quality Problems

General: The quality of the water in the Galveston Bay system varies markedly from one section of the bay to another. However, the sections are all interconnected and cannot be truly separated from the water quality standpoint. The direction and velocity of the wind governs, to a large extent, which section of the bay may be affected by a particular waste discharge at a particular time.

In general, the waters of East Bay, Trinity Bay, and West Bay are of better quality than the waters of the rest of the bay system. However, under certain wind conditions, the overall good quality of the waters of these bays is reduced by waters entering from other sections.

East Bay: Water quality data indicates a generally good quality of water in East Bay. An average DO value of 7 mg/l and an average MPN of 10 are indicators of this good quality.

The variation of water temperatures through the year reflects the shallow nature of the bay as does the lack of material variation of temperature between the surface and the bottom of the bay. A lack of substantial variations between the surface and bottom salinities is also a reflection of the shallow depth, as well as a reflection of the lack of fresh water inflow into this portion of Galveston Bay. At the present time, East Bay receives about 0.03 million gallons per day (mgd) of treated domestic sewage, about 0.02 mgd of oil field brines, and some drainage from septic tanks serving individual households and commercial establishments. These discharges do not appear to be causing water quality problems at this time. However, there will probably be an increasing problem with these discharges as the area grows.

Trinity Bay: At the present time, there is considerably more fresh water inflow into Trinity Bay than into any other portion of the Galveston Bay system. There are indications that the fresh water inflow (Trinity River) results in some water quality problems in Trinity Bay, since it appears to contain a high concentration of algal cells and other biological life. The algal cells probably accounted for both the high DO of 10 mg/l through their activity and the low DO of zero through the biological load exerted by the cells dying off in the bay. Both high and low DO's and higher MPN's were measured in the Trinity River channel through the bay. Undoubtedly, the discharge of septic tank effluents from the Anahuac area also contributes to the oxygen and MPN problems.

The waters of the Galveston Bay system cannot be separated in the true sense. Under the proper tidal and wind conditions, the waters of Trinity Bay are affected by the waters of northeast Galveston Bay which in turn are affected by the waters of the Houston Ship Channel and discharge in the Baytown area. Water quality impairment in Trinity Bay from this source is sporadic.

Trinity Bay is closed to commercial oyster harvesting at the present time, principally because of the high MPN counts. Other

uses of the bay do not appear to have been materially affected, except in isolated areas near waste discharge points.

At the present time, Trinity Bay receives approximately 0.9 mgd of treated domestic sewage, 0.2 mgd of septic tank effluents, and 0.05 mgd of industrial wastes. Elimination of the septic tank effluents and upgrading of the quality of the industrial wastes are needed for the immediate future. In order to provide continued protection for the quality of the waters, the present sewage treatment plants will need to be expanded as the area grows. The development of planned upstream water supply reservoirs on the Trinity River will probably reduce the overall fresh water flow to the bay.

Northeast Galveston Bay: The water quality of northeast Galveston Bay tends toward uniformity. This is probably due to its being completely surrounded by other waters except for a contact with land in the northwest corner in the vicinity of Baytown. The quality of the waters of its southeastern portion is generally good. The water quality of its northwestern portion varies to some extent due to the effects of waters from the Houston Ship Channel reaching it under certain tidal and wind conditions. Its quality is also affected by discharges in the Baytown and Cedar Bayou areas.

The southeastern portion of northeast Galveston Bay is open to commercial oyster harvesting, while the northwest portion is closed. While major fish kills have only been experienced in the smaller bays of its extreme northwestern end, there are oxygen variations in this portion of the Galveston Bay. These variations are probably due to algal activity brought on by discharged organic materials.

At the present time, it is estimated that northeast Galveston Bay receives about 3.5 mgd of treated domestic sewage, about 5.5 mgd of industrial wastes with varying degrees of treatment, and about 72 mgd of industrial cooling water. Improvement in the treatment and control of these waste waters is needed at the present time in order to protect the quality of the bay waters.

Northwestern Galveston Bay: The most severe water quality problems occur in the northwestern portion of Galveston Bay. The Houston Ship Channel, a major source of pollutional material, is considered as a part of this portion of the Galveston Bay system for purposes of this report. In addition, Clear Lake, an arm off the main bay, experiences pronounced quality problems.

All of the northwestern portion of Galveston Bay is closed to commercial oyster harvesting. In addition, there have been massive fish kills due to oxygen depletion in the vicinity of the mouth of the landlocked portion of the Houston Ship Channel.

Excluding the Houston Ship Channel and Clear Lake which are covered below, northwestern Galveston Bay receives about 3.6 mgd of treated domestic sewage from five sewage treatment plants. These plants provide both primary and secondary treatment for the sewage. In addition, about 0.9 mgd of industrial process waters are discharged from five industrial outlets. Some 737 mgd of once-through cooling water is circulated by a thermal power plant.

The Houston Ship Channel is considered here in three sections; namely, (1) the open water section through the bay; (2) the semi-landlocked section between Morgan's Point and the San Jacinto Monument; and (3) the landlocked portion above the San Jacinto Monument. The quality of the waters in sections 1 and 2 is determined by the quality of the water in section 3 since they receive very little direct discharge of waste waters.

The Texas Water Pollution Control Board (TWPCB) has indicated it intends to maintain the quality of Galveston Bay for all legitimate uses. Since the waters of section 1 of the channel are a part of the open bay waters, it follows that the quality of the water in this section of the channel should be suitable for all uses. The quality of the waters of section 1 of the channel is generally lower than that quality desirable for propagation of fish life and recreation.

The TWPCB has indicated that section 2 of the channel is to be maintained as a buffer zone between the landlocked portion of the channel and the open bay waters. Further indications are that while the waters are to be primarily maintained for navigation and commercial use, their quality is to be maintained high enough to support fish life and limited recreation (boating). The quality in this section has deteriorated at times, which resulted in massive fish kills.

The portion of the Houston Ship Channel upstream from the San Jacinto Monument is completely landlocked. The TWPCB has indicated that this portion of the channel is to be maintained for navigation and commercial purposes. In addition, it is to be maintained free from hazardous, aesthetically objectionable, and nuisance conditions. While the quality of the waters of this portion of the channel generally meets the indicated conditions, there have been fires on

the channel and nuisance and aesthetically objectionable conditions have existed. There have also been allegations that the waters of this portion of the channel are highly corrosive to the boats and ships using the channel.

The overlying water quality consideration, in connection with the Houston Ship Channel, is the effect of the waters from the upper portion (section 3) on the waters of the remainder of the channel and Galveston Bay. There is no doubt that these waters affect the quality of the waters of the San Jacinto River estuary, the bays along the lower portion of the channel, and Galveston Bay. At the present time, the most serious problem is oxygen depletion.

The 25-mile stretch of the Houston Ship Channel above the San Jacinto Monument receives directly, or from its tributaries, approximately 143 mgd of treated domestic sewage from some 110 sewage treatment plants. While all the municipalities and other governmental agencies provide primary and secondary treatment for the sewage, some of the plants have deteriorated while others have become overloaded. Operational problems have been noted in many of the smaller plants.

The 25-mile stretch also receives approximately 782 mgd of industrial process and cooling waters from some 173 industrial outlets. Since the process waters and cooling waters are often discharged together, it is not practical to attempt a summation of these waters by type. However, it is estimated that about three-fourths of the industrial water is from cooling operations (may be recirculated channel water), and about one-fourth is process water.

The discharges shown above combine in the landlocked portion of the Houston Ship Channel and result in a body of water practically devoid of oxygen. The appearances range from clear, to brown, to black. The organic content is high, as measured by BOD. The quality of the channel deteriorates upstream to the Houston Turning Basin.

If the gradual feeding by tidal action of the upstream channel water to the lower reaches could be relied upon, the quality control problem would be reduced to an almost straight line degradation in water quality. However, from time to time, upstream rains tend to push the polluted waters of the upper portion of the channel into the lower portions as a slug and without any appreciable dilution from downstream rains. This type occurrence has resulted in major fish kills due to oxygen depletion in the lower channel and upper Galveston Bay.

Clear Lake is a small bay off the midportion of northwestern Galveston Bay. It is presently being used for recreational purposes, including boating and water skiing. The TWPCB has indicated its intention to protect this recreational use and has an active program for this purpose underway. Nevertheless, the lake does have water quality problems at the present time resulting from a relatively heavy load of treated domestic sewage and small industrial discharges resulting in high bacterial loadings and oxygen depletion. Algal growth approaching bloom proportions occur from time to time.

The greatest threat to the quality of Galveston Bay as a whole is heavy algal growth. Rapid growth of algal cells in the lake and their subsequent discharge and die-off in Galveston Bay places a heavy organic load on the bay waters. This appears to have caused some oxygen depletion problems in a limited area of the bay proper. In addition, the bacterial density as measured by MPN coliform for limited areas of Galveston Bay appears to be affected by bacterial cells passing from Clear Lake to Galveston Bay.

The assimilative capacity of Clear Lake appears to have been overtaxed by the cumulative discharges from a number of small sewage treatment plants. While these plants provide primary and secondary treatment, the residual organic and nutrient materials still place a heavy load on the lake. These residuals need to be reduced even further or removed from the lake's watershed.

At the present time, Clear Lake receives from its tributary area about 10 mgd of treated domestic sewage from 28 sewage treatment plants and 1 mgd of industrial process water from 11 industrial outlets. The domestic sewage receives both primary and secondary treatment, while the industrial wastes receive varying degrees of treatment. In addition, some 564 mgd of once-through cooling water is circulated through Clear Lake by a thermal power plant.

Southwest Galveston Bay: The quality of the waters of southwest Galveston Bay is what might be termed marginal. The apparent water quality degradation is near-shore based. This shore based degradation covers a considerable area since discharges are spaced rather regularly along the shoreline. The open waters of this section of Galveston Bay receive the muted effects of the shore installations and the waters from the Houston Ship Channel.

Practically all of southwest Galveston Bay is closed to commercial oyster harvesting. There have been fish kills in limited areas along the shorelines. While there may have been some overall reduction of

recreational activities, it is difficult to determine to what degree any reduction was due to water quality. Some areas where the water quality would not be considered suitable for recreation are used quite heavily for water skiing, boating, fishing, etc.

There are four major source areas for pollutional material in the southwestern portion of Galveston Bay. These are:

1. Dickinson Bayou area
2. Texas City area
3. Galveston area
4. Highland Bayou

The discharges in the Dickinson Bayou area, Galveston area, and Highland Bayou area are primarily treated domestic sewage. The discharges in the Texas City area are principally partially treated industrial wastes. These discharges are summarized as follows:

Area	Municipal Discharges (mgd)	No. Plants	Industrial Discharges (mgd)	No. Outlets
Dickinson Bayou	1.7	3	0.09	5
Texas City	5.0	2	122.00	23
Galveston	6.8	3	0.04	3
Highland Bayou	2.3	4	-	-
Other	1.9	1	-	-

No attempt has been made to separate process waters from cooling waters in the above tabulation. In fact, in the Texas City area, the industrial waste waters combine in ditches with the composite waste waters being discharged to the bay at a much smaller number of points than the outlets listed above. Without a complete study, it is not possible to identify the individual discharges. The proximity of the industries to each other lends itself to construction of a central industrial treatment plant for all the waste waters of the area.

West Bay: The quality of the waters of West Bay is generally good. While isolated instances of low DO concentration have been recorded, these appear to be rare occurrences. It is not believed that any of the legitimate uses of this portion of Galveston Bay have been materially curtailed due to poor water quality at this time. However, the area surrounding the bay is growing both domestically and industrially. Water quality degradation may occur as the area grows unless the quality of existing and new discharges is diligently controlled.

At the present time 0.2 mgd of domestic sewage which receives primary and secondary treatment is discharged by two sewage treatment plants, Some 3.3 mgd of industrial effluents are discharged by three industrial plants.

Waste Discharge Improvement Measures

In general, the major step needed to improve the quality of the waters of Galveston Bay is the reduction of the amount of organic material being discharged to the bay and its tributaries. This can be accomplished by one of several plans ranging from one large plant to treat the waste from the entire area to improved waste treatment facilities at each individual waste discharge point. The overall solution lies somewhere between these two extremes. Full evaluation would require a complete study of the engineering, legal and economic aspects of possible approaches.

Based on a limited appraisal of the problems and the location of discharge points, suggested improvement measures are proposed as shown in the summary table.

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